[redacted]

ABUNDANCE AND TIMING OF SUMMER RUN CHUM SALMON (*ONCORHYNCHUS KETA*) AND WATER QUALITY IN CLEAR CREEK-HOGATZA RIVER, NORTHWEST ALASKA

By

Gareth K. VanHatten

RECOMMENDED:

John Kelley

A Tyler

Ronald L. Smith
Advisory Committee Chair

Department Head

APPROVED:

A Tyler
Dean, School of Fisheries and Ocean Sciences

Dean of the Graduate School

5-18-00
Date

ABUNDANCE AND TIMING OF SUMMER RUN CHUM SALMON (*ONCORHYNCHUS KETA*) AND WATER QUALITY IN CLEAR CREEK-HOGATZA RIVER, NORTHWEST ALASKA

A

THESIS

Presented to the Faculty

of the University of Alaska – Fairbanks

in Partial Fulfillment of the Requirements

for the degree of

MASTER OF SCIENCE

By

Gareth K. VanHatten, B.S.

Fairbanks, Alaska

August 2000

ALASKA
QL
618.3
V36
2000

RASMUSON LIBRARY
UNIVERSITY OF ALASKA FAIRBANKS

ABSTRACT

Biological, climatological, and hydrological data were collected from Clear Creek – Hogatza River from 1995 to 1997. A counting tower and partial weir were constructed to estimate chum salmon (*Oncorhynchus keta*).

Partial hour counts were tested to see if they adequately estimated full hour counts. Chi-square tests indicated all estimates based on partial hour counts differed significantly from hour counts. ANOVA indicated no partial hour count differed significantly from the hour counts. Relative error analysis showed counts greater than 20 minutes produced unbiased estimates of hour counts.

The three year estimated average was 96,032 salmon with the average peak occurring on 3 July. A 1:1 sex ratio existed with the average female length being 566 mm and male length being 599 mm. Climatological and hydrological conditions had minimal effect on the outcome of the project.

TABLE OF CONTENTS

	Page
ABSTRACT	3
LIST OF FIGURES	5
LIST OF TABLES	6
ACKNOWLEDGEMENTS	7
INTRODUCTION	8
METHODS	12
STANDARD COUNTING METHODS	12
COMPARISON OF COUNTING METHODS	13
FISH COLLECTION AND MEASUREMENTS	18
WATER QUALITY	19
RESULTS	20
RUN TIMING AND STRENGTH	20
COMPARISON OF COUNTING METHODS	21
FISH COLLECTION AND MEASUREMENTS	22
WATER QUALITY	27
DISCUSSION	28
RUN TIMING AND STRENGTH	28
COMPARSION OF COUNTING METHODS	30
FISH COLLECTION AND MEASUREMENTS	35
WATER QUALITY	38
CONCLUSION	39
REFERENCES	41

LIST OF FIGURES

Page

Figure 1: Geographic location of study site Clear Creek – Hogatza River 43

Figure 2: Daily and seasonal summer chum escapement estimates for 1995, 1996, and 1997, Clear Creek – Hogatza River 44

Figure 3: Peak return dates for summer chum salmon from 1995, 1996, and 1997, Clear Creek – Hogatza River 45

Figure 4: Variability in expanded 10 minute estimates compared to hour counts, Clear Creek – Hogatza River 46

Figure 5: Variability in expanded 50 minute estimates compared to hour counts, Clear Creek – Hogatza River 47

Figure 6: Relationship of 10 and 50 minute estimates to hour counts, Clear Creek-Hogatza River 48

LIST OF TABLES

Page

Table 1: 1995, 1996, and 1997 daily summer chum salmon estimates, Clear Creek – Hogatza River 49

Table 2: Summary of statistical tests conducted on data collected from 1997, Clear Creek – Hogatza River 50

Table 3: Percentage of age composition per stratum for 1996 and 1997, Clear Creek – Hogatza River 51

Table 4: Sex ratio and age composition of summer chum salmon sampled from 1996 and 1997, Clear Creek – Hogatza River 52

Table 5: Sex ratios of summer chum salmon separated by strata for 1996, Clear Creek – Hogatza River 53

Table 6: Sex ratios of summer chum salmon separated by strata for 1997, Clear Creek-Hogatza River 54

Table 7: Sex ratios of summer chum salmon separated by strata for 1997, Clear Creek-Hogatza River 55

Table 8: Length at age of summer chum salmon for 1996, Clear Creek-Hogatza River 56

Table 9: Length at age of summer chum salmon for 1997, Clear Creek-Hogatza River 57

Table 10: Hydrological and climatological data for 1996, Clear Creek-Hogatza River 58

Table 11: Hydrological and climatological data for 1997, Clear Creek-Hogatza River 59

ACKNOWLEDGEMENTS

The Clear Creek – Hogatza River project was part of a multi-agency study to collect baseline information on the summer chum salmon population within the Koyukuk drainage. I would like to thank my late Grandfather Ralph Nelson, Grandfather Bob Wenzel, and Uncle Gordon Olin for their encouragement for me to finish my academic career. I would also like to thank my family and Dr. R. Smith (Professor Emeritus – UAF) for their support during my academic career. In addition I would like to thank Dr. A. Tyler (Associate Dean for School of Fisheries and Ocean Sciences – UAF), Dr. J. Kelley (Professor School of Fisheries and Ocean Sciences – UAF), Mr. Paul Headlee, Mr. C. Kretsinger (Fisheries Biologist, U.S. Department of the Interior – Bureau of Land Management), Mr. D. Senecal-Albrecht (Bering Sea Fishermen's Association), and Mr. R. Holder (A.Y.K. Regional Resource Development Biologist, Alaska Department of Fish and Game – Division of Commercial Fisheries) for their helpful input before, during, and after the project time period. This multi-agency approach allowed for the continuation of a five year study.

I would also like to thank Mr. Bergman Sam and Mr. Steven Toby, native elders from the villages of Huslia and Koyukuk, respectively. Ms. Kristina Evans, a native youth from Rampart and Mr. Steve Stroka for their commitment to the gathering of the information printed in this thesis.

INTRODUCTION

The goal of many agencies is to manage a fishery population, which exhibits some type of yield, whether maximum, sustained, or optimal. Census data are frequently used as a measure of fish production and may provide an index of the success in regulation of the commercial fishery (Neilson and Geen 1981). To reach a specified yield within a particular fishery, an estimate (either total or relative index) of the number of fish migrating to spawn must be made. Many authors have documented that salmon stock abundance fluctuates widely from year to year, which has given rise to the many different methods for estimating population abundance (Cousens et al. 1982). Such methods are the basic component for the development of stock management policies and the management of individual stocks (Jessop and Harvie 1990). Accurate escapement estimates are required to determine the exploitation rates, marine survival, and spawner recruit relations of Pacific salmon (*Oncorhynchus spp.*) stocks (Labelle 1994). A component of these methods is to use observers, which visually count fish and estimate escapement. The accuracy of observer counts is becoming increasingly important because more reliable estimates of total escapement are needed for population studies. In addition, inaccurate counts can produce biased estimates of optimum harvest rate and escapement in stock recruitment analysis (Jones and Quinn 1998).

Accurate salmon escapement counts on Yukon River tributaries are important for gauging management strategy guidelines of state and federal agencies (Melegari 1996). These estimates are used for annual harvest management guidelines, i.e. predicting run strength based on brood year returns, monitoring long term population trends, and influencing current U.S./Canada salmon treaty negotiations for allocating trans-boundary chinook (*Oncorhynchus tshawytscha*) and chum salmon (*O. keta*) stocks (Daum and Osborne 1999). The Yukon River spans two countries and is made up of many diverse systems, which causes high variability in escapement estimates between systems. Due to the large area of these the many diverse systems it is not economically feasible to collect direct estimates on every system (Bevan 1961). The chinook, chum, and coho salmon (*O. kisutch*) fisheries comprise the majority of subsistence and personal use harvests of villagers living along the Koyukuk, Yukon, and Tanana Rivers. To be effective, management of the Yukon River fisheries requires knowledge of the number of salmon harvested by the subsistence and personal users (Borba and Hamner 1999). State and federal agencies base their yearly management strategies, pre-season forecasts, in-season monitoring studies, and post-season escapement estimates, on the more productive systems. In Alaska these systems include the Anvik, Andreafsky, Koyukuk, Chandalar, Chena, Salcha, and Tanana Rivers (Sandone 1995). There are many different methods for collecting escapement data. Of these, fish counting towers and weirs are the most economical in remote areas.

Through the Alaska National Interest Lands Conservation Act there is a responsibility by state and federal agencies to ensure salmon populations are conserved in their natural diversity, international treaty obligations are met, and subsistence opportunities are maintained (Wiswar 1998). An important component of this mandate is providing accurate spawning escapement estimates for the major salmon stocks in the drainage. Three of the five salmon species, stated above, utilize 1,931 kilometers of the

RASMUSON LIBRARY
UNIVERSITY OF ALASKA FAIRBANKS

Yukon River and 446 kilometers of the lower Tanana River (Buklis and Barton 1984, Bergstrom et al. 1995). Chum salmon enter the Yukon River in two major groups that are referred to as summer and fall runs (Bergstrom et al. 1995). Genetic studies reported by Wilmot et al. (1992) show that these two runs are distinct and differ in characteristics, i.e. run timing, spawning locations, and morphology. The Alaska Department of Fish and Game-Division of Commercial Fisheries (ADF&G-DCF) and U.S. Fish and Wildlife Service-Fairbanks Fishery Resource Office (USFWS-FFRO) have reported that most summer chum salmon spawn in the lower 800 km of the Yukon River and in the Tanana River system.

Clear Creek, a tributary of the Hogatza River is a small, clear water system located in Koyukuk National Wildlife Refuge, northwestern Alaska (Figure 1). This small, productive system is one of many different systems that provide natural resources to the subsistence lifestyles of the villagers from Huslia and Hughes. It is this area that has been the focal point of concern over the past 5-6 years due to the possibility of extracting minerals by Taiga Mining Company. Due to the extensive database concerning escapement collected by ADF&G-DCF, this system, along with the tributaries within it is designated as being important for spawning, rearing, or migration of anadromous fishes (State of Alaska Department of Fish and Game-Habitat Division 1998). The information collected by ADF&G-DCF has prompted local agencies to place a high priority on this system to monitor the physical and chemical variables over at least one salmon life cycle. Salmon escapement assessments on the watershed by ADF&G-DCF have been limited to aerial surveys and/or foot surveys of specific spawning reaches (Barton, ADF&G-DCF,

personal communication 1998). The surveys have been conducted during specific time intervals, which is normally when peak spawning is occurring. The results from these surveys allowed ADF&G-DCF to set an escapement goal of 8,000 fish (Barton, ADF&G-DCF, personal communication 1994). Due to safety concerns with using fixed wing aircraft, aerial surveys have been discontinued since 1993 (Sandone, ADF&G-DCF, personal communication 1994). With the exception of the discontinued aerial surveys there has been a minimum of management activity conducted in this area.

The objectives for this study are listed below:

1. Estimate daily and seasonal summer chum salmon returns to Clear Creek-Hogatza River using visual counting methods (tower counts)
2. Estimate escapement counts from using a correction factor for times not counted. The actual count is represented by the time counted, usually 30 to 45 minutes. The estimated count is represented by the time not counted, usually 15 to 30 minutes.
3. Estimate age, sex composition, and length frequency of summer chum salmon spawning population.
4. Collect, on a daily basis, baseline water quality information on turbidity, settleable solids, pH, and water temperature.

A set of null hypotheses was generated with these objectives in mind. The null hypotheses for the respective objectives were:

H_{O1A}: There is no difference in mean numbers of returning salmon among years in Clear Creek.

H_{O1B}: There is no difference in peak date of return for salmon returning to Clear Creek.

H_{O2}: There is no difference in population counts based on continuous (60 min/hr) observations and observations made during portions of the hour (10, 15, 20, etc. min/hr).

H_{O3A}: There is no difference between mean lengths from year to year.

H_{O3B}: There is no difference between sex ratios from year to year.

H_{O4}: There is no difference in measurable qualitative indices such as turbidity, settleable solid, pH, and water temperature between years.

METHODS

Standard Counting Methods

During the 1995, 1996, and 1997 field season a crew member counted a minimum of 30 minutes per hour during a six hour time frame. The data collected from this time frame were used to estimate daily returns of summer chum salmon. The information recorded would be the number of salmon migrating upstream, the number of salmon migrating downstream and the number of minutes counted. This information was recorded on write in the rain data sheets. Total hour estimates were calculated from partial hour counts by multiplying them by an expansion factor. These hour estimates were then summed over a 24 hour period, which provided a daily estimate of salmon migration. To date a variance estimator has not been formulated for escapement on this system due to the dynamic characteristics of this run.

Comparison of Counting Methods

For the purpose of clarification hour counts are the actual number of fish migrating past the tower for the entire hour and hour estimates are the number of fish moving past the tower during a certain time frame (a portion of an hour), multiplied by an expansion factor. This expansion factor is an estimator for calculating the number of salmon moving past the viewing platform during those times of the hour when the observer was not counting. The expansion factor was calculated by dividing 60 minutes by the number of minutes counted. Example: a 10 minute count would give an expansion factor of 6, 20 minute count would give an expansion factor of 3, etc. The equation used for estimating salmon migration is:

$$N^* = N \times (60/m)$$

where:

N^* = estimated salmon in that hour

N = number of salmon visually counted

m = number of minutes counted

$(60/m)$ = expansion factor

Salmon migration was monitored on a 6 hour time frame by one crew member. Starting at 0000 hours at the beginning of the study the crew member would monitor the number of salmon moving upstream and downstream for the whole hour. After the first 10 minutes of monitoring migration, the crew member would record the number of salmon moving upstream and downstream. This procedure of recording migration movement would continue at 5 minute intervals, after the first 10 minutes, to encompass the whole hour. To avoid fatigue over the 6 hour time frame an additional crew member would rotate into the schedule every other hour.

During the 18 hour time frame when crew members were not counting for the full hour, each observer was required to count a minimum of 30 minutes. The enumeration of salmon movement was recorded on hourly data forms at the end of each hour. To keep track of the number of salmon migrating upstream and downstream, the crew member used hand held tally counters. To calculate the total number of salmon migrating into the system, the number of salmon moving downstream was subtracted from the number of salmon moving upstream.

I used three different statistical tests to see if there is a significant difference between hour estimates and hour counts. These tests include Chi-square goodness of fit , Analysis Of Variance (ANOVA) and relative error.

The first test, Chi-square (χ^2) was used to test the hypothesis that a population distribution estimated by a random sample is identical to a hypothesized or expected distribution. If hour estimates, based on counts of 10, 15, 20, 25 etc. minutes represent observed frequencies and 60 minute counts represent expected frequencies, hypothesis H_{O2} is rejected if Pearson's statistic exceeds or equals the value of $\chi^2_{\alpha,\nu}$ for ν = k-1 degrees of freedom and α level of significance (Kirk 1990). A critical value for Chi-square (χ^2) will be used to measure significance between hour estimates and hour counts. To test this hypothesis I used the equation below:

$$\chi^2 = \Sigma[(\text{Observed} - \text{Expected})^2 / \text{Expected}]$$

Observed = hour estimates (10, 15, 20, etc)

Expected = hour counts

The second test, ANOVA, a statistic test for difference between means of more than two samples, was used to see if hour estimates were significantly different from hour counts. For calculation purposes the hour estimates were divided into 10 populations, which encompassed the full hour. From each population I had a sample size equal to 103. Configuring my data to the following format I was able to test a restated H_{O2} hypothesis:

H_{O2}: $\mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5 = \mu_6 = \mu_7 = \mu_8 = \mu_9 = \mu_{10}$

where μ_1 = mean 10 minute estimates

μ_2 = mean 15 minute estimates

μ_3 = mean 20 minute estimates

μ_4 = mean 25 minute estimates

μ_5 = mean 30 minute estimates

μ_6 = mean 35 minute estimates

μ_7 = mean 40 minute estimates

μ_8 = mean 45 minute estimates

μ_9 = mean 50 minute estimates

μ_{10} = 60 minute counts

The third test follows the same procedure stated in Seibel (1967), where he used relative error to see if the seasonal sum of hour estimates provided an unbiased estimate of the seasonal sum of hour counts. Using the equation:

$$Y_i = X_i + \varepsilon_i$$

where

X_i = hour counts

Y_i = hour estimates

ε_i = error by which X_i is estimated by Y_i

and if the sum of the error is randomly distributed with a mean equal to zero when summed, the equation over all possible counts would become:

$$\Sigma Y_i = \Sigma X_i + \Sigma \varepsilon_i$$

If the sum of the error is equal to zero, then the seasonal sum of the hour estimates will provide an unbiased estimate of the seasonal sum of the hour counts (Seibel 1967). Relative error, which ideally, over the season should sum to zero, will determine bias. The relative error is calculated using the equation below:

$$\text{R.E.} = 100\ [\Sigma\ (\text{Hour Estimates}) - \Sigma\ (\text{Hour Counts})] / \Sigma\ (\text{Hour Counts})$$

Assuming the population is a normal population I was able to use the coefficient of determination (r^2) and coefficient of non-determination (k^2) with the correlation coefficient (r) to examine how much an estimate varied from the actual count (Kirk 1990). The correlation coefficient provided a measure of the linear relationship between hour estimates and hour counts (Seibel 1967). According to Kirk (1990) the correlation coefficient will give two indications of the data set:

1. The strength of the relationship, represented by the extent to which the value (r) differs from zero, and

2. The direction of the relationship, represented by the sign of r.

The equation for the correlation coefficient is given below:

$$r = \frac{\sum XiYi - \frac{\sum(Xi)\sum(Yi)}{n}}{\sqrt{\left[\sum Xi^2 - \frac{\left(\sum Xi\right)^2}{n}\right]}\sqrt{\left[\sum Yi^2 - \frac{\left(\sum Yi\right)^2}{n}\right]}}$$

The results from the tests conducted on the data of an assumed normal population will show the sample correlation coefficient as an unbiased estimator of the population correlation coefficient (ρ). The coefficients of determination and non-determination values were used to conduct a Student's t-test. The result from the t-test will show how likely a sample correlation coefficient would have been obtained if the correlation between hour estimates and hour counts were equal to zero (Kirk 1990).

Fish Collection and Measurements

Age, sex, and length (A-S-L) data were collected from summer chum salmon for the 1996 and 1997 field season. This information was extracted from weekly samples or strata during the study. These strata represent an attempt to sample the escapement population for A-S-L information in relative proportion to the total run (Sandone 1995). Samples were taken over a 1-2 day period within each of four weekly strata. The number and dates of strata were determined before the study was started and based on previous studies.

A 15 meter beach seine (1 cm, 40 meshes deep) was used to collect a target sample size of 160 salmon. The target sample size was predetermined from past studies and from consultation with USFWS-FFRO personnel. The seine was stretched across the mouth of Clear Creek, then brought downstream in a wide arc and pulled to shore. Salmon caught were identified, sexed, and measured with the information recorded on field data sheets. Lengths of salmon were measured from mid-eye to fork of caudal fin and read to the nearest 5 mm in 1996 and to the nearest 1 mm in 1997. In addition, all fish species caught were recorded on these data sheets. The adipose fin was clipped on sampled chum salmon to prevent repeat sampling during subsequent sampling events. A Student's t-test ($p<0.05$, Zar 1999) was used to compare mean lengths of males and females for each year and between years.

Scale analysis was the preferred method for aging salmon. One scale was removed from the optimal area of the salmon, two rows above the lateral line and on a diagonal line from the posterior end of the dorsal fin to the anterior end of the anal fin, according to ADF&G-DCF sampling protocol (ADF&G-DCF personal communication 1995). Age determination follows the European method, which is practiced by ADF&G-DCF (Ligneau, personal communication, 1985). In this study the number of years in fresh water plus the number of years in salt water represent the age of salmon. A designation of 0.3 or 0+ .3 would indicate a 4 year old with the salmon migrating to sea as a fry, or underyearling, and returning from the ocean after three winters at sea (Groot and Margolis 1998).

Water Quality

Hydrological data included water temperature (°C), water level (m), pH, water color, turbidity (NTU), and settleable solids (ml/L). Water temperature was recorded from a thermometer suspended one foot below the surface for 15 minutes. A staff gauge, surveyed by BLM 1.21 km upstream from the mouth of Clear Creek and Hogatza River was used to record relative water height. A digital, hand held Whatman, model pHA 300, pH meter was used to record water pH. Turbidity was measured using a HACH 2008 turbidimeter and expressed in nephelometric turbidity units (NTU). Settleable solids were measure using a Volumetric Imhoff Cone and expressed in ml/L. The samples used for testing pH, turbidity, and settleable solids were collected near the observation tower and triple rinsed in their respective containers. These data was recorded on field data forms.

Climatological data included rainfall (cm), wind velocity (kph) and direction and air temperature (°C). A rain gauge, placed in an area devoid of vegetation, was used for measuring previous 24 hour precipitation. Air temperature was read from a thermometer hanging in the shade.

RESULTS

Run Timing and Strength

The run timing and strength of summer chum salmon for 1995, 1996, and 1997 is presented in Table 1 and Figure 2. The results from the data collected in 1995, 1996, and 1997 show that there is some variability in the run size between years. The estimated escapement count of chum salmon in 1995 was 116,735 with an average migration rate of 3,891 salmon per day. In 1996 and 1997 the estimates of escapement and daily migration rate decreased. In 1996 the escapement was 100,912 and the average migration rate was 3,479 salmon per day. The 1997 data showed a low escapement of 76,454 salmon and the average migration rate was 2,831 salmon per day (Table 1).

The peak return dates from 1995, 1996, and 1997 are presented in Figure 3. The peak of the run for 1995 occurred on 7 July with an estimated escapement of 7,911 salmon. The peak return date in 1996 occurred sooner, on 30 June, with an estimated 6,686 salmon. In 1997 the peak of the run occurred on almost the same time as in 1995. The peak occurred on 8 July but with a smaller estimate of 6,670 salmon running on that date (Figure 3).

Comparison of Counting Methods

The results of the different statistical tests are presented in Table 2. The results from the Chi-square show that the calculated value for 10 minute estimates was 1781, which is greater than the critical value of 127.69 (Zar 1999). A Chi-square value of this size is questionable. According to the characteristics of this equation I am showing what the spread between hour estimates and hour counts is. A high Chi-square value would indicate that the two distributions have a wide spread. This is the case because fish movement during any one hour is sporadic, including upstream and downstream movements. This type of movement produces variability too great for the Chi-square statistic to handle (Table 2). The calculated Chi-square values between hour estimates 10 and 50 minutes are greater than the critical value, thus I fail to support the null hypothesis for 10 minute estimates based on anything less than full hour counts (Table 2)

The results from the ANOVA tests show there is no significant difference between the mean 10 minute estimate and the mean full hour count (Table 2). Furthermore, the ANOVA results shows that over the entire season any hour estimate (10, 15, 20, etc.) that is used to estimate escapement is adequate enough to fully represent the hour counts.

Relative errors for each hour estimate were calculated and summed over the season (Table 2). Under the assumption of a normal distribution population a z-statistic was performed on the relative error for each hour estimate. The z-statistic was used to test if the relative errors were significantly different from zero. The combination of these two statistics show which hour estimates are unbiased estimates for hour counts. The relative error for 10 and 15 minute estimates was –16.98 and –10.91, respectively. These results indicates that the relative errors are not equal to zero and are thus biased estimators of hour counts. In addition the z-test shows a p-value for 10 minute estimates to be equal to 0.02 ($p < 0.05$). I will use 10 and 50 minute estimates for comparison purposes to see the relationship between hour estimates and hour counts. 10 minute estimates had a correlation coefficient of 0.63, a coefficient of determination of 0.40, and a coefficient of non-determination of 0.60. In comparison, 50 minute estimates had a correlation coefficient, coefficient of determination and non-determination of 0.99, 0.97, and 0.03, respectively. The results for 10 minute estimates show that 40% of the variance of the hour estimates can be explained by the hour counts with 60% of the variance being accounted for by other unknown variables. Conversely, 50 minute estimates show that

97% of the variance in hour estimates can be explained by the hour counts, with 3% of the variance being explained by some other variable (Table 2). In addition there is a better linear relationship between 50 minute estimates and hour counts than 10 minute estimates when compared to hour counts (Figure 4, 5 and 6).

Fish Collection and Measurements

1996

Age composition

During the 1996 field season crew members collected 478 scales, which is 75% of the goal set before the start of the study. Out of the 478 scales 166 were classified as unreadable. The age classes for the 1996 spawning population were comprised of age 4 (0.3), age 5 (0.4), and age 6 (0.5) salmon (Table 3). The run was made up of mainly age 0.3 (42%) salmon, followed by 22% age 0.4, 2% age 0.5, and 35% of the scales were unreadable (Table 3).

Sex-Age Composition

The 1996 run had a sex ratio of 1.3 females to 1 male, 57% females, 43% males (Table 4). The male age distribution was predominantly age 0.3 (17%), followed by age 0.4 (9%) and age 0.5 (1%). There were 76 unreadable scales, which was 37% of the male distribution (Table 4). The female age distribution closely resembled the male age distribution with predominantly age 0.3 (25%), age 0.4 (13%), age 0.5(1%) and 19% unreadable (Table 4).

The first stratum included predominantly age 0.4 males (14%), followed by age 0.4 females (12%), age 0.3 males (11%), age 0.3 females (6%), age 0.5 females (1%), age 0.5 males (1%), and 55% unreadable (Table 5). There was a higher percentage of age 0.3 salmon in the second stratum than the first. There were 23% age 0.3 males, 19% age 0.3 females, 13% age 0.4 females, 10% age 0.4 males, and 1% age 0.5 males and females. There were a lower percentage of unreadable scales (33%) during the second stratum. The third stratum showed predominantly age 0.3 females (49%). The next highest percentage was age 0.3 males (16%), followed by age 0.4 females (13%), then age 0.4 males (4%), age 0.5 females (1%), and age 0.5 males (1%). The third stratum showed the lowest percentage of unreadable scales (16%) (Table 5). With the exception of the third stratum, the proportion of unreadable scales was high enough to, potentially, change the age distributions described above.

Length at Age

The average length of all 1996 male salmon was 598 mm with a minimum of 520 mm and a maximum of 680 mm (Table 8). The average length of age 0.3 males was 580 mm with a minimum length of 520 mm and a maximum length of 649 mm. The average length of age 0.4 males was 605 mm with a minimum of 550 mm and a maximum of 670 mm. The average length of age 0.5 males was 630 mm with a minimum of 605 mm and a maximum of 670 mm. The average length of males with unreadable scales was 601 mm with a minimum of 525 mm and a maximum of 680 mm (Table 8). The average length of all females was 567 mm with a minimum of 495 mm and a maximum of 660 mm (Table 8).

The average length of age 0.3 females was 581 mm with a minimum of 530 mm and a maximum of 660 mm. The average length of 0.4 females was 554 mm with a minimum of 495 mm and a maximum of 630 mm. The average length of 0.5 females was 575 mm with a minimum of 540 mm and a maximum of 600 mm (Table 8). The average length of females with unreadable scales was 572 mm with a minimum of 500 mm and a maximum of 650 mm (Table 8).

1997

Age Composition

The age class distribution for the 1997 population was different from the 1996 distribution. The 1997 run were predominantly age 0.4 (70%) followed by age 0.3 (23%) and age 0.5 (1%) (Table 4). During the 1997 field season the crew members collected 333 scales, which was 52% of the goal set before the start of the study. Out of the sample size of 333 scales 18 (5%) of them were unreadable. The sample was compromised of 56% males and 44% females (Table 4).

Sex-Age Composition

The same year class distribution returned in 1997 as in 1996 with 23% age 0.3, 70% age 0.4, 1% age 0.5, and 5% unreadable (Table 4). The male distribution was 13% age 0.3, 41% age 0.4, 1% age 0.5, and 2% unreadable (Table 4). The females were distributed as follows: 11% age 0.3 females, 30% age 0.4 females, 0% age 0.5 females, and 4% unreadable scales (Table 4).

The first stratum (Table 6) was composed primarily of males (65%), which was dominated by age 0.4 salmon. The male distribution consisted of 49% age 0.4, 13% age 0.3, and 4% age 0.5. The 35% female distribution was comprised of 24% age 0.4, 9% age 0.3, 0% age 0.5 and 3% unreadable. The second stratum still showed a high percentage of males, with a 2.8 (74%) to 1 (26%) male to female ratio. There were 61% age 0.4 males, 21% age 0.4 females, 11% age 0.3 males, 1% age 0.3 females, 0% age 0.5 male and females. There were 4% unreadable females and 1% unreadable males (Table 6). In the third stratum the female to male ratio was 1.3 (56%) to 1 (44%). Age 0.4 salmon was the most prominent accounting for 61% of the entire sample; 34% were females and 27% were males (Table 7). Age 0.3 salmon contributed about one third of the sample with 17% being females and 13% males. There were no age 0.5 salmon in the sample. 5% of the female scales were unreadable and 4% of the male scales were unreadable (Table 7). The fourth stratum had almost the same percentage of males and females, 43% and 57%, respectively. There were more age 0.4 salmon, 42% females and 28% males. Age 0.3 salmon consisted of 13% females and 15% males and no age 0.5 salmon were sampled. 2% of the female scales were unreadable and there were no unreadable scales for males (Table 6).

Length at age

The average length of 1997 male salmon was 600 mm with a minimum length of 523 and a maximum length of 688 mm (Table 9). The average length of age 0.3 males was 580 mm with a minimum of 523 mm and a maximum of 649 mm. The average length of 0.4 males was 605 mm with a minimum of 534 mm and a maximum of 688 mm. The average length of 0.5 males was 633 mm with a minimum of 611 and a maximum of 647 mm. The average length of males with unreadable scales was 596 mm with a minimum of 569 mm and a maximum 632 mm (Table 9). The average length of females was 566 mm with a minimum of 506 mm and a maximum of 630 mm. The average length of age 0.3 females was 553 mm with a minimum of 506 mm and a maximum of 598 mm. The mean length of 0.4 females was 570 mm with a minimum of 520 mm and a maximum of 630 mm. There were no age 0.5 females sampled. The average length of females with unreadable scales was 568 mm with a minimum of 530 mm and a maximum of 625 mm (Table 9).

The results from the Student's t-test shows that the 1996 average male length is not significantly different from the 1997 average male length ($t_{0,05(2),389}$, $p=0.54$). In addition the 1996 average female length is not significantly different from the 1997 average female length ($t_{0.05(2),418}$, $p=0.26$).

Water Quality

The hydrological and climatological data for 1996 is shown in Table 10. This watershed is quite dry during the summer months. With the exception of 3 days during the study time period it did not rain. The average daily rainfall for the 28 day period was 0.08 cm. The water temperature had an average of 10.5 °C with a low of 9 °C and a high of 13 °C. The initial staff gauge measurement was recorded at 0.60 m. The average water height was 0.60 m with a low of 0.49 m and a high of 0.82 m (Table 10).

During the course of the study there was very little activity, i.e. mining, in the system to affect the chemical variables, pH and turbidity. The average pH was 7.46 with very little variation, minimum of 6.93 and maximum of 7.88. The turbidity was quite low, having very little impact on the observers' sight. The average turbidity levels were 5.39 NTU with a low of 3.29 NTU and a high of 20.00 NTU.

The hydrological data collected for the 1997 field season showed very little change from the 1996 field data (Table 11). In 1997 this system was dry with an average precipitation per day of 0.1 cm. The average water temperature was 10.7 °C with a low of 6 °C and a high of 13.5 °C. The initial staff gauge measurement was recorded at 0.70 m. The average height was 0.63 m with a low of 0.60 m and a high of 0.70 m.

As in 1996, the mining company did not conduct any activity during the 1997 study period that might have caused changes in chemical values. The pH was slightly acidic with an average value of 6.6. The range was minimal with a low of 6.2 and a high of 7.0. Turbidity was quite low with an average NTU of 5.8. The range had a low of 2.7 NTU and a high of 12.3 NTU (Table 11).

DISCUSSION

Run Timing and Strength

The results show that the summer chum populations can differ in size from year to year. The 1995 chum run had a higher magnitude than the runs in 1996 and 1997. A fluctuation in escapement numbers for salmon populations is typical of most systems in Alaska. For example, the Kvichak River has annual fluctuations for sockeye salmon (*O.*

nerka) that range from 0.25 million to 9.5 million salmon (Becker 1961). The Nulato River chum salmon population decreased from 236,890 in 1995 down to 129,694 salmon in 1996 (Paulus 1997). The Gisasa River chum salmon population dropped from 157,589 salmon in 1996 down to 31,800 in 1997 (Melegari, USFWS-FFRO, personal communication 1998). Although there is an apparent downward trend in the number of chum salmon returning to Clear Creek-Hogatza River, a much longer time series of return estimates would be needed to document or establish such a trend.

To date I have not found a variance estimator that applies to this salmon run. I have reviewed the literature and found variance estimators for specific studies (Stuby 1999, Becker 1961, Paulus 1997, Brannian 1990), but the formulas do not meet the parameters for this study. The main reasoning for this disparity was that most variance estimators are system and/or species specific.

The peak return dates for 1995, 1996, and 1997 for Clear Creek-Hogatza River are shown in Figure 2. In 1995 and 1997 the return dates are within a day of each other, even though the summer chum salmon run entered the Yukon River six days apart (Bergstrom, ADF&G-DCF, personal communication 1999). The number of migrating fish on the peak date of return was lower in 1996 and 1997 than 1995. Even though the size of the run was different for each year the magnitudes of daily salmon passage were comparable. These data give an indication that there might be a cyclical pattern in date of return for specific age classes, but more data is needed to document such a pattern. However each run is probably independent of the other, which would make them unrelated and prohibit me from trying to explain this phenomenon.

The biological information gathered during this study maybe useful for fishery managers in trying to understand the timing of future runs. It has been noted that early runs normally are better than late runs (Schultz, ADF&G-DCF, personal communication 1998). The explanation for this variation in run timing is unknown but historical data have shown that the late runs are more compact with a higher migration rate per day.

It has been reported that salmon runs throughout Alaska could be affected by a combination of anthropogenic and natural factors in either fresh water or the marine environment (Kruse 1998). The data collected from this study in combination with data from other test sites on the lower Yukon River gives me the necessary information to calculate swimming speed. Under the assumption that the first 10% of the run caught in lower Yukon River test sites are destined for Clear Creek-Hogatza River, I calculated a swimming speed of 79.5 km/d. Using results from Groot and Margolis (1998) this speed would be in their calculated range for chum salmon (70-106 km).

Comparison of Counting Methods

The results show that Chi-square and ANOVA statistical tests do not adequately test the data. I can assume that these tests did not adequately test the data because their assumptions were not met. Assuming a normal distribution, a large Chi-square value would occur, i.e. 10 minute estimate = 1781, due to a large disagreement between the hour estimate and hour count frequencies (Zar 1999). The large difference result from the variation in run timing at the beginning of the run or during different times of the day. For example a 10 minute estimate on 25 June from 1-2 p.m. was 2 salmon. Conversely a 10 minute estimate from 10-11 a.m. on 4 July was –111 salmon. Therefore the variation of –109 salmon between these two time periods will cause the summed calculated Chi-square values to be high. Due to the natural behavior of salmon migration, where this is a wide variation in migration movement, it becomes difficult to test the data using the Chi-square statistic.

The results from the ANOVA test shows that there is no significant difference between any hour estimate and full hour count. I believe this statistic test does not adequately test the data because the data set tests the difference between the mean estimate and the mean hour count. In addition the results are based on estimates collected from the first portion of the hour. These results indicate that, based on ANOVA, any estimate based on counts for any portion of the full hour gives an adequate representation of the hour counts.

The result from relative error shows that this technique meaningfully tests hour estimates against hour counts. The relative error for 10 minute estimate of each hour does not allow for reliable estimation of daily and seasonal salmon escapements. The degree of relative error that accumulates is dependent upon the sample counting time (Seibel 1967, Becker 1961, Jessop and Harvie 1990). The longer an observer counts the less uncertainty surrounds the estimates. Menard and Cole (1999) used relative error techniques for abundance estimates on the Kanektok River but were unable to come to any conclusions about its usefulness due to small sample size. The results from this study has shown that to adequately estimate summer chum escapement in Clear Creek-Hogatza River the most feasible time frame to count is greater than 20 minutes. Any hour estimate based on a time frame less than 20 minutes will produce a relative error that exceeds 10%. A 10% relative error was established prior to conducting the study as an arbitrary limit on bias. I can tolerate a significant amount of relative error for individual hour estimates if these errors tended to cancel out and produce only small relative errors in the total season estimate (Seibel 1967). In this study 10-15 minute estimates do not adequately represent full hour counts, which produces a misrepresentation of the total counts that causes the estimates to deviate from the true counts (Jessop and Harvie (1990).

Becker (1961), Neilson and Geen (1981), and Stuby (1999) reported using estimators to enumerate salmon populations for their respective studies. Unfortunately, to date, I have not been able to design a variance estimator for the Clear Creek-Hogatza River system population estimate. This type of estimation method requires the sample to be recorded in a systematic manner through time. Unfortunately there is no variance estimator available that is tested for my data set. My data set can be used to design a variance estimator because the data set has total hour counts, which can be used to check the estimator.

Another cause for not formulating a variance estimator could be due to the high variability in hour estimates from one hour to the next. Individual 10 minute estimates are basically point estimates and because the magnitude of each estimate fluctuates widely it becomes necessary to record hour estimates every day. In addition, there is a high variation in migration rate, which causes an observer to over and/or underestimate salmon escapement. A field crew operating the Nulato River salmon escapement project utilized partial hour counts to estimate chum salmon populations, but had to increase the counting time to 30 minutes (Paulus 1997). The Kwethluk River counting tower maintained a 10 minute counting period but expanded their viewing area to include both banks of the river. In essence they were using 20 minute counts to estimate population size of four salmon species (Chris and Cappiello 1999). Upon analysis of the counting method (tower counts and partial weir) and statistical test (relative error) used for this study the results show that 20 minute counts would yield unbiased estimates of escapement and be more efficient than 30 or 60 minute counts.

The geographic location of salmon producing systems is an important factor for deciding how much modification is required for a sampling method. Many southwestern systems are close to the marine environment and once salmon enter freshwater they are moving directly upstream. The counting crews for these areas are able to count migrating salmon moving in a unidirectional manner. Therefore, counting for 10 minutes each hour allows adequate estimation of daily and seasonal salmon escapements. In comparison, for those systems that are close to the spawning grounds, salmon mill about trying to home in on their natal streams. In Clear Creek-Hogatza River the crew has to record both the upstream and downstream movement of migrating salmon, therefore 10 minute counts are inadequate.

The use of a modified counting tower-partial weir technique to estimate chum escapement worked well for my study. Across the state there are many different biologists who use this method to study the salmon species that are bank oriented, namely pink (*O. gorbusha*) and sockeye (*O. nerka*) salmon (Bevan 1961, Cousens et al. 1982). Due to the characteristics of the Clear Creek-Hogatza River system it was necessary to incorporate and modify this method for my study. I was able to modify the standard counting tower method to include:

1. Counting fish in mid-stream
2. Counting for longer than 10 minutes
3. Counting downstream in addition to upstream moving fish

As with most studies that are conducted in the field different types of error can be introduced to the estimation. During the course of the field season this project was susceptible to the forces of nature and, in some cases, caused counting to be halted. Of the many variables that introduce error to the data, hydrological conditions are the most drastic ones. Any amount of rain occurring in this system will greatly affect the escapement estimation. Not only does rain raise the water level but it also increases the turbidity level. When these hydrological conditions change occurs, observers are unable to view salmon movement. To compensate for missed counts we followed the methods as stated in Sandone (1995):

1. A single hour count that was missed would be estimated by averaging the hour count before and after the missed count.
2. If hour counts were missed for a portion of the day, the expanded daily count for that day would be estimated by dividing the expanded partial daily count by the mean proportion of expanded counts for the corresponding hours for the first day before and after having full 24 hour counts.
3. If a full daily count was missed, the estimate for that day would be calculated as the mean salmon passage for the day before and the after the missed count.

4. If counting were not conducted for two or more days, the estimate for those days would be determined by extrapolating the last full day of counts after counting restarted.

These methods for filling missed estimates are questionable for my data. My data show that during the early and late portions of the run there was a large variation in migration rate from one 10 minute count to the next. Conversely during the peak of the run when variation is minimal Sandone's method should work well.

Observer error is another that can be introduced into the estimation, which can be corrected. A method many fishery biologists use to check for observer error is the use of an additional observer during a portion of the hour. To overcome this error I conducted an experiment in which two observers were counting at the same time but separated by 100 m. Observer one recorded the number of salmon migrating and compared that number to the second observer's number. In this study the average number of fish per minute for observer one was within 0.32 fish per minute of observer two.

Fish Collection and Measurements

The number and location of salmon spawning streams along the west coast of North America are so numerous, many escapement estimates are based on relatively few counts (Neilson and Geen 1981). The addition of this information to other enumeration projects can contribute biological data to a growing database, which provide managers with a more thorough understanding of salmon population characteristics. The data I collected can be used in conjunction with other salmon enumeration projects (Gisasa River weir, Nulato River counting tower, Anvik River sonar). The comparison of data collected between these different systems will allow fishery managers to gain a better understanding of the overall biological characteristics of summer run chum salmon in the Koyukuk and lower Yukon River drainages. Even though my study was conducted on a small system, the data collected has become invaluable. By conducting this study I found out that there were more salmon utilizing this system than was apparent from aerial surveys. This thesis supplies important data and analysis of summer chum salmon but more information is needed to manage the Clear Creek-Hogatza River fishery.

During the 1996 and 1997 runs there was a very dominant age class present. In 1996, with the exception of unreadable scales, the summer chum salmon run was predominantly age 0.3 and in 1997 the dominant age class was 0.4. With this information I can calculate the brood year for these age classes, which for my study was 1992. There are a couple of explanations for such a dominant age class that spans over two years. First, the 1992 brood year was such a good year that there was a high survival rate among the progeny and/or second, the 1992 brood year was an average year the and the brood years 1991 and 1993 failed (Lignau, ADF&G-DCF, personal communication 1999). Due to the lack of information collected these are only speculations as to what occurred during the 1991, 1992, and 1993 brood years lifecycle.

In comparison with other systems, Clear Creek-Hogatza River had an age composition that closely resembled the Nulato River salmon escapement project but not the Gisasa River project. The Gisasa River project produced results that showed two different age classes dominating the run during 1996 and 1997. In 1996 age 0.4 fish amount to 50% of the run and in 1997 70% were age 0.4 (Melegari, USFWS-FFRO, personal communication 1999). This indicates that the brood years 1991 and 1992 were very good in producing chum salmon for that system. The Nulato River project had almost the same percentage of age 0.3 salmon in 1996 and age 0.4 salmon in 1997 when compared to my study. The results from the 1996 study show 55% age 0.3 and 67% age 0.4 in 1997 (Paulus 1997, Huttunen, ADF&G-DCF, personal communication 1999). Using the data from the Gisasa River and the Nulato River projects it is probable that the brood years 1991 and 1993 did not fail and that the 1992 brood year was an exceptional year. Again, this conclusion is speculative due to lack of information gathered at other study sites along the lower Yukon River. In addition, there were enough unreadable scales in the 1996 sample to, theoretically, change the dominant year class for that run. A possible method that would correct the high proportion of unreadable scales would follow the one used for collecting scales from chinook salmon. The protocol for this method is to collect three scales from the preferred area.

Reports have been written which speculate on why multiple and/or single age classes within a salmon population might increase or decrease. During a salmon's lifecycle they are affected by both freshwater and marine variables. Depending on the environment in which salmon are living during a time of change, single or multiple age classes could be affected. A change in the freshwater habitat such as an increase in turbidity or decrease in flow due to mining could greatly affect a single age class. In addition any changes in the marine environment could affect multiple age classes (Kruse 1998). Natural conditions are not the only factors that affect age classes but also anthropogenic factors. Commercial fishing, in either environment, depending on the gear used, could remove single age classes from the gene pool. The type of gear used for commercially harvesting salmon removes the faster growing members of a stock more heavily than those of slower growth because they are the first to be caught (Ricker 1981).

Water Quality

There was no difference in the data collected for hydrological and climatological data from 1996 and 1997. This could be because this small system has the same response to natural disturbances each year. For example, the water shed had the same response to precipitation in 1996 and 1997 but the timing of the occurrence was different.

An attribute of this system is that it remained relatively dry during the project for both years, thus allowing us to record escapement information. The river system responded to rainfall similarly in both years. Episodes of rain were followed by transient increases in stream height and turbidity. Even though there was no significant difference in hydrological and climatological data between years, there were effects, due to stream height and turbidity, on data collection. In 1996 when 4.2 cm of rain fell the crew was unable to count fish for a 30 hour period. Conversely, in 1997 when 2.22 cm of rain fell the water level and turbidity increased considerably but not enough to prevent counting fish. In essence the data collected for hydrological and climatological will be a bench mark against which changes related to mining activity can be evaluated.

CONCLUSION

The conclusions below are in response to the null hypothesis stated at the beginning of this thesis.

1. I failed to reject or support the H_{O1A} because at the time of analysis I did not have a variance estimator for the population estimator. The lack of a variance estimator makes it impossible to statistically test for differences in annual returns. ADF&G-DCF has/is wrestling with this very problem and unfortunately have been unable to adequately formulate and test a variance estimator around the escapement estimate. The inability to find a variance estimator for estimating escapement for this system has to deal with a systematic sample through time.
2. I have supported H_{O1B} because the data from the 1996 and 1997 field season shows that there is very little variation in peak date of return.
3. One out of the three statistical tests conducted on the data support the H_{O2} while the other two tests fail to support it. Hour estimates based on less than 60 minutes counting periods when tested statistically show either:

   a) all hour estimates are significantly different, Chi-Square (χ^2),

   b) all hour estimates are not significantly different, ANOVA, or

   c) based on relative error calculations, hour estimates less than 20 minutes produces an unacceptable level of error.
4. I have supported H_{O3A} because the mean lengths from 1996 and 1997 are not significantly different from each other.

5. I was unable to support or reject the H_{O3B} because I was unable to formulate a variance estimator for these ratios.
6. I was able to support the H_{O4} because the water quality measurements were very similar in the two study years (pH, turbidity, and water height $p<0.05$).

REFERENCES

Becker, C. D. 1961. Estimating red salmon escapements by sample counts from observation towers. U.S. Fish and Wildlife Service Fishery Bulletin 61: 355-369.

Bergstrom, D. J., A. C. Blaney, K. C. Schultz, R. R. Holder, G. J. Sandone, D. J. Schneiderhan, and J. H. Barton. 1995. Annual management report Yukon area, 1993. Alaska Department of Fish and Game. Regional Information Report Number 3A95-10. Anchorage, Alaska.

Bevan, D. E. 1961. Variability in aerial counts of spawning salmon. J. Fish. Res. Brd. Can. 18(3): 337-347.

Borba, B. M. and H. H. Hamner. 1999. Subsistence and personal use salmon harvest estimates Yukon area, 1998. Alaska Department of Fish and Game – Division of Commercial Fisheries. Regional Information Report 3A99-27. Anchorage, Alaska.

Brannian, L.K. 1990. Estimates of total abundance, exploitation rate, and migratory timing of chinook salmon runs in the Yukon River, 1982-1986. Alaska Department of Fish and Game-Division of Commercial Fisheries, Fishery Research Bulletin No. 90-03.

Buklis, L. S. and L. H. Barton. 1984. Yukon River fall chum salmon biology and stock status. Alaska Department of Fish and Game – Division of Commercial Fisheries. Information Leaflet Number 239.

Chris, J. L. and T. Cappiello. 1999. Kwethluk River counting tower salmon assessment project, 1998. Alaska Department of Fish and Game – Commercial Fisheries Division. Regional Information Report No. 3A99-20. Anchorage, Alaska.

Cousens, N. B., G. A. Thomas, S. G. Swan, and M. C. Healy. 1982. A review of salmon escapement estimation techniques. Can. Tech. Rep. Fish. Aq. Sc. 1108:15-32.

Daum, D. W. and B. M. Osborne. 1999. Enumeration of Chandalar River fall chum salmon using split-beam sonar, 1998. U.S. Fish and Wildlife Service – Fishery Resource Office. Alaska Fisheries Technical Report Number 50. Fairbanks, Alaska.

Groot C. and L. Margolis. 1998. Pacific Salmon Life Histories. UBC Press. Vancouver, British Columbia

REFERENCES (Continued)

Jessop, B. M. and C. J. Harvie. 1990. Evaluation of designs of periodic count surveys for the estimation of escapement at a fishway. N. Am. J. Fish. Manage. 10:39-45.

Jones III, E. L. and T. J. Quinn II. 1998. Observer Accuracy and Precision in aerial and foot survey counts of pink salmon in southeast Alaska stream. N. Am. J. Fish. Manage. 18:832-846.

Kirk, R. E. 1990. Statistics: An Introduction. Third edition. Holt, Rinehart and Winston, Fort Worth, Texas.

Kruse, G. E. 1998. Salmon run failures in 1997-1998: A link to anomalous ocean conditions? AK. Fish. Res. Bull.. 5(1):55-63.

Labelle, M. 1994. A likelihood method for estimating pacific salmon escapement based on fence counts and mark-recapture data. Can. J. Fish Aq. Sci. 51: 552-556.

Melegari, J. L. 1996. Abundance and run timing of adult salmon in the Gisasa River, Koyukuk National Wildlife Refuge, Alaska. 1995. U.S. Fish and Wildlife Service – Fishery Resources Office, Alaska Fisheries Data Series Number 96-1. Fairbanks, Alaska.

Menard, J. and A. Caole. 1999. Kanektok River counting tower cooperative project, 1997. Alaska Department of Fish and Game – Commercial Fisheries Division. Regional Information Report No. 3A99-16. Anchorage, Alaska.

Neilson, J. D. and G. H. Geen. 1981. Enumeration of spawning salmon from spawner residence time and aerial counts. Trans. Am. Fish. Soc. 110:554-556.

Paulus, R. D. 1997. Nulato River salmon escapement project, 1996. Alaska Department of Fish and Game – Division of Commercial Fisheries. Regional Information Report No. 3A97-32. Anchorage, Alaska.

Ricker, W. E. 1981. Changes in the average size and average age of pacific salmon. Can. J. Fish. Aq. Sci. 38:1636-1656.

Sandone, G. J. 1995. 1995. Nulato River salmon escapement study, 1994. Alaska Department of Fish and Game – Division of Commercial Fisheries. Regional Informational Report 3A95-19, Anchorage.

REFERENCES (Continued)

Seibel, M. C. 1967. The use of expanded ten-minute counts as estimates of hourly salmon migration past counting towers on Alaskan Rivers. Alaska Department of Fish and Game – Division of Commercial Fisheries Informational Leaflet 10. Juneau, Alaska

State of Alaska Department of Fish and Game – Habitat Division. 1998. Catalog of waters important for spawning, rearing or migration of anadromous fishes. Interior Region Resource Management Region VI. Juneau, Alaska.

Stuby, L. 1999. Salmon studies in interior Alaska, 1998. Alaska Department of Fish and Game – Division of Sport Fish. Fishery Data Series No. 99-13. Anchorage, Alaska.

Wilmot, R. L., R. Everett, W. J. Spearman, and R. Baccus. 1992. Genetic stock identification of Yukon River chum and chinook salmon 1987 to 1990. Progress report. U.S. Fish and Wildlife Service. Alaska Fish and Wildlife Research Center, Fisheries Management Service. Anchorage, Alaska.

Wiswar, D. W. 1998. Abundance and run timing of adult salmon in the south fork Koyukuk River, Kanuti National Wildlife Refuge, Alaska. 1997. U.S. Fish and Wildlife Service – Fishery Resources Office, Alaska Fisheries Data Series Number 98-1. Fairbanks, Alaska.

Zar, J. H. 1999. Biostatistical Analysis. Fourth edition. Prentice – Hall, Inc. Upper Saddle River, New Jersey.

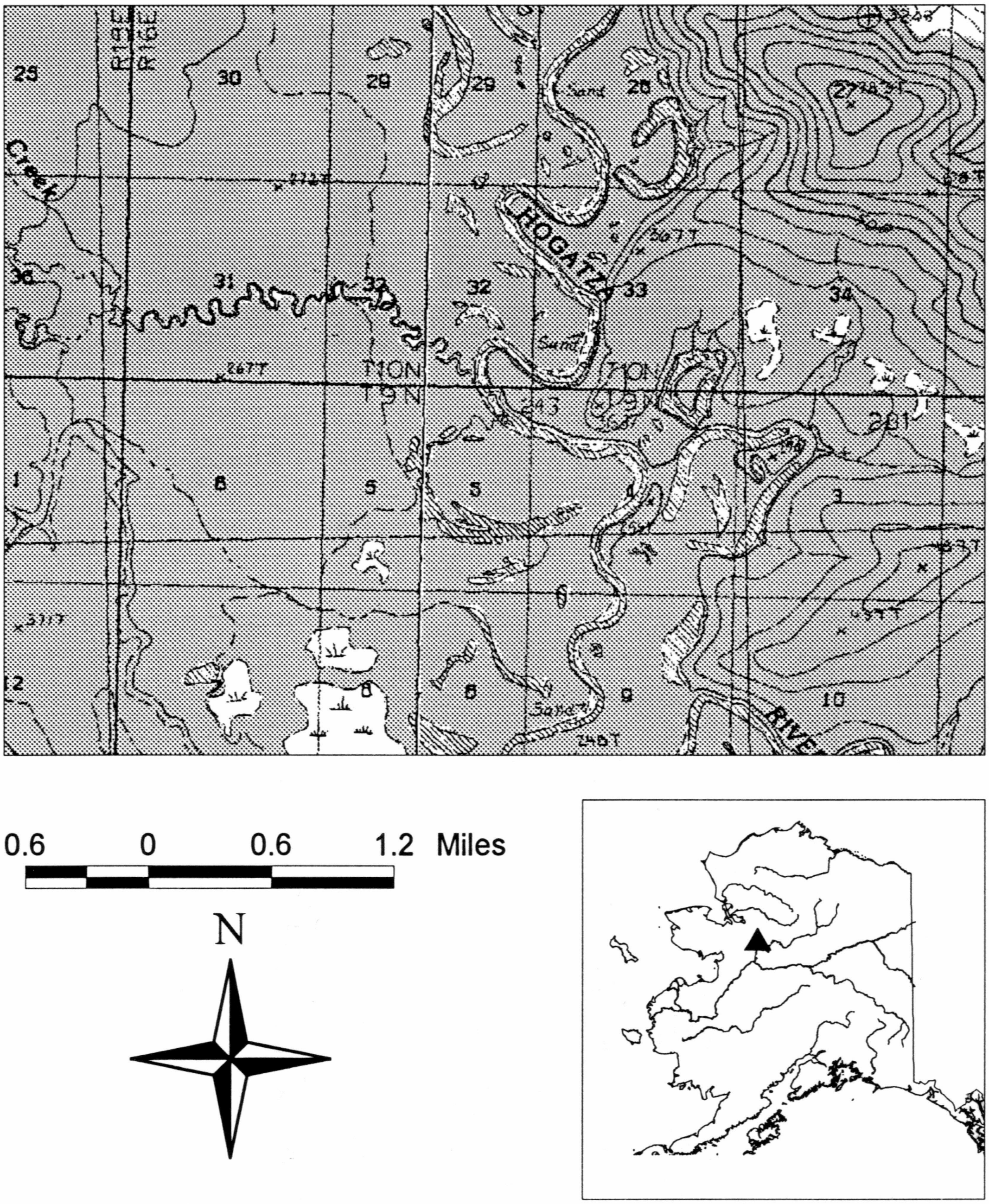

Figure 1: Geographic location of study site, Clear Creek-Hogatza River

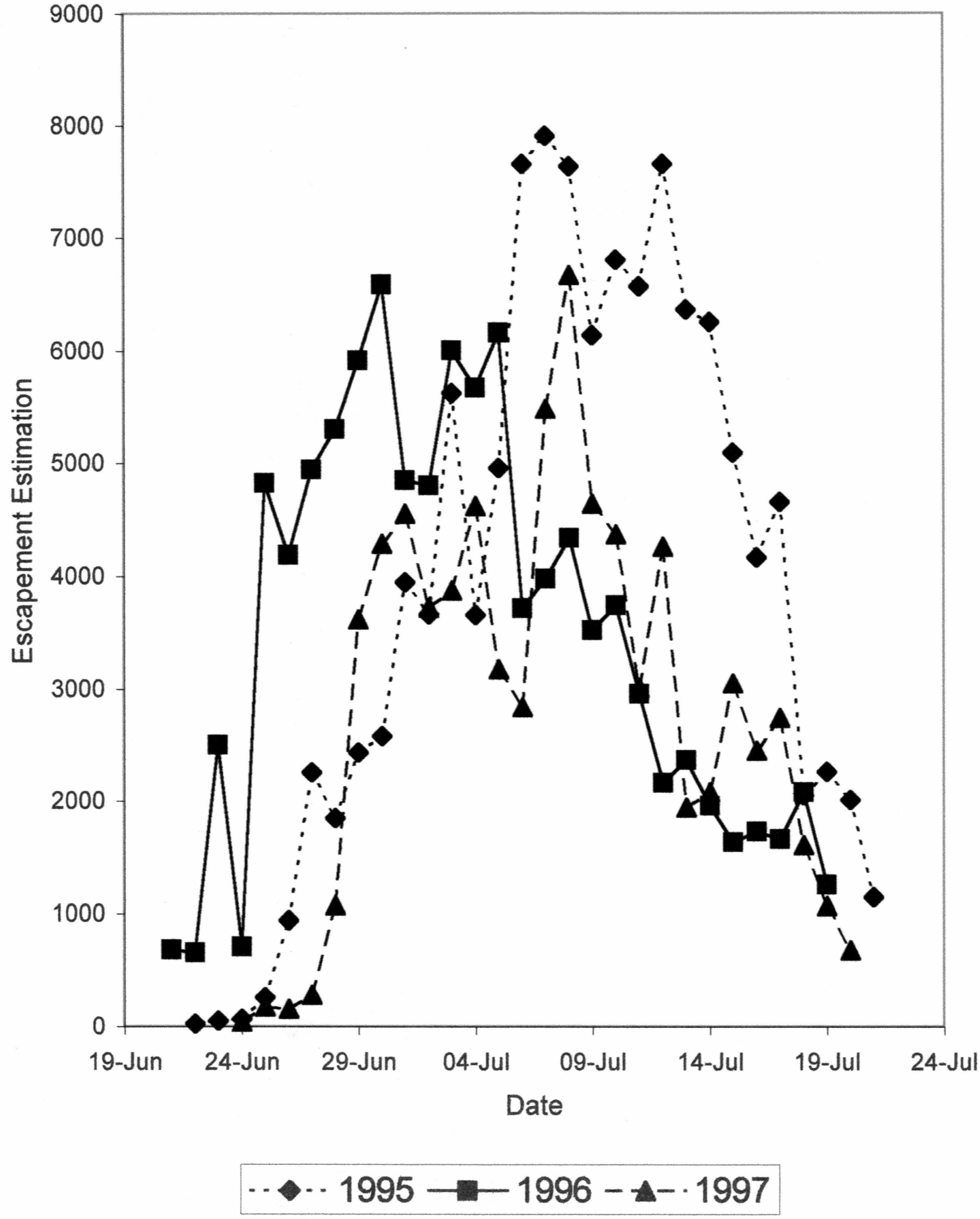

Figure 2: Daily and seasonal summer chum escapement estimates for 1995, 1996, and 1997, Clear Creek-Hogatza River

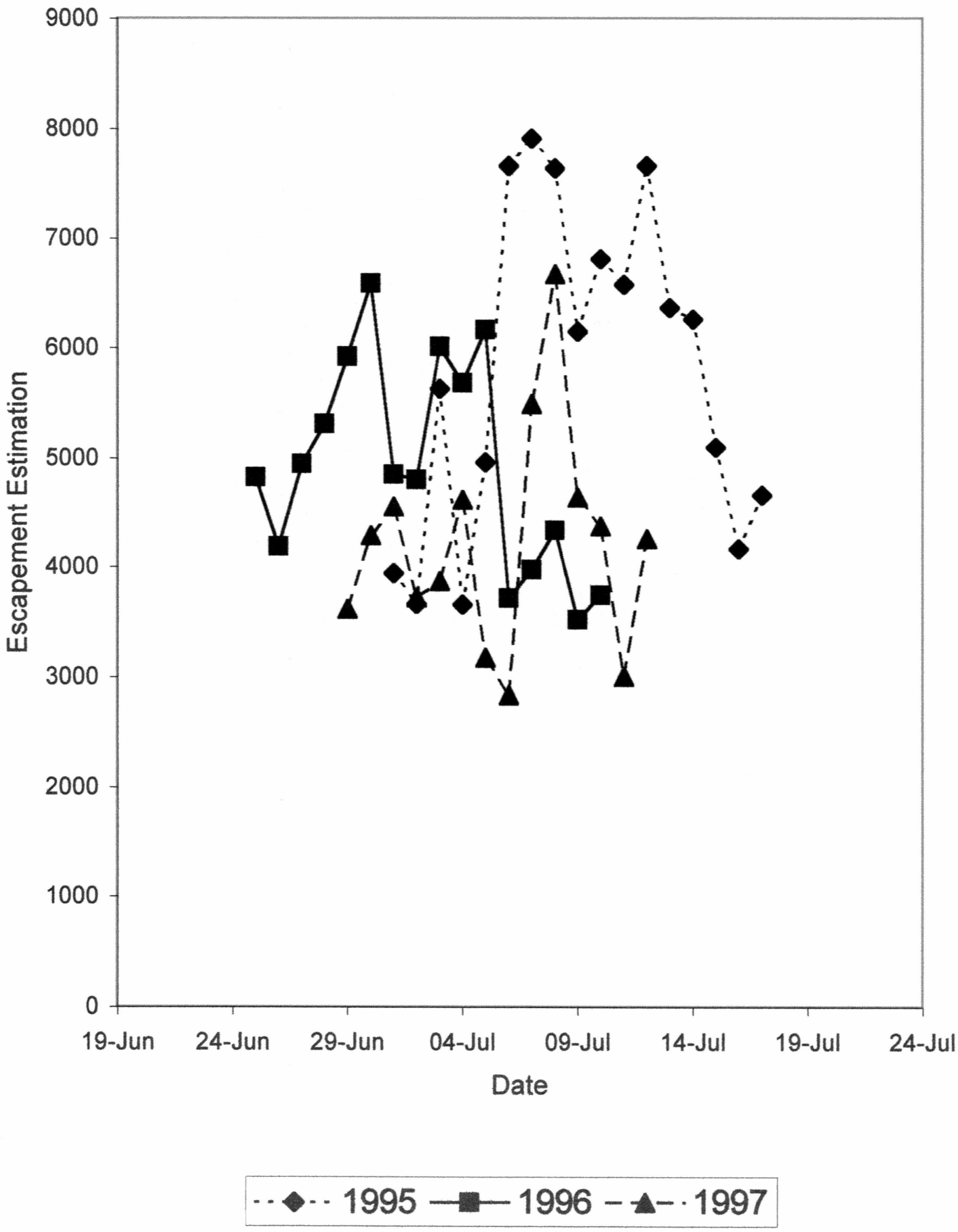

Figure 3: Peak return dates for summer chum salmon from 1995, 1996, and 1997, Clear Creek-Hogatza River

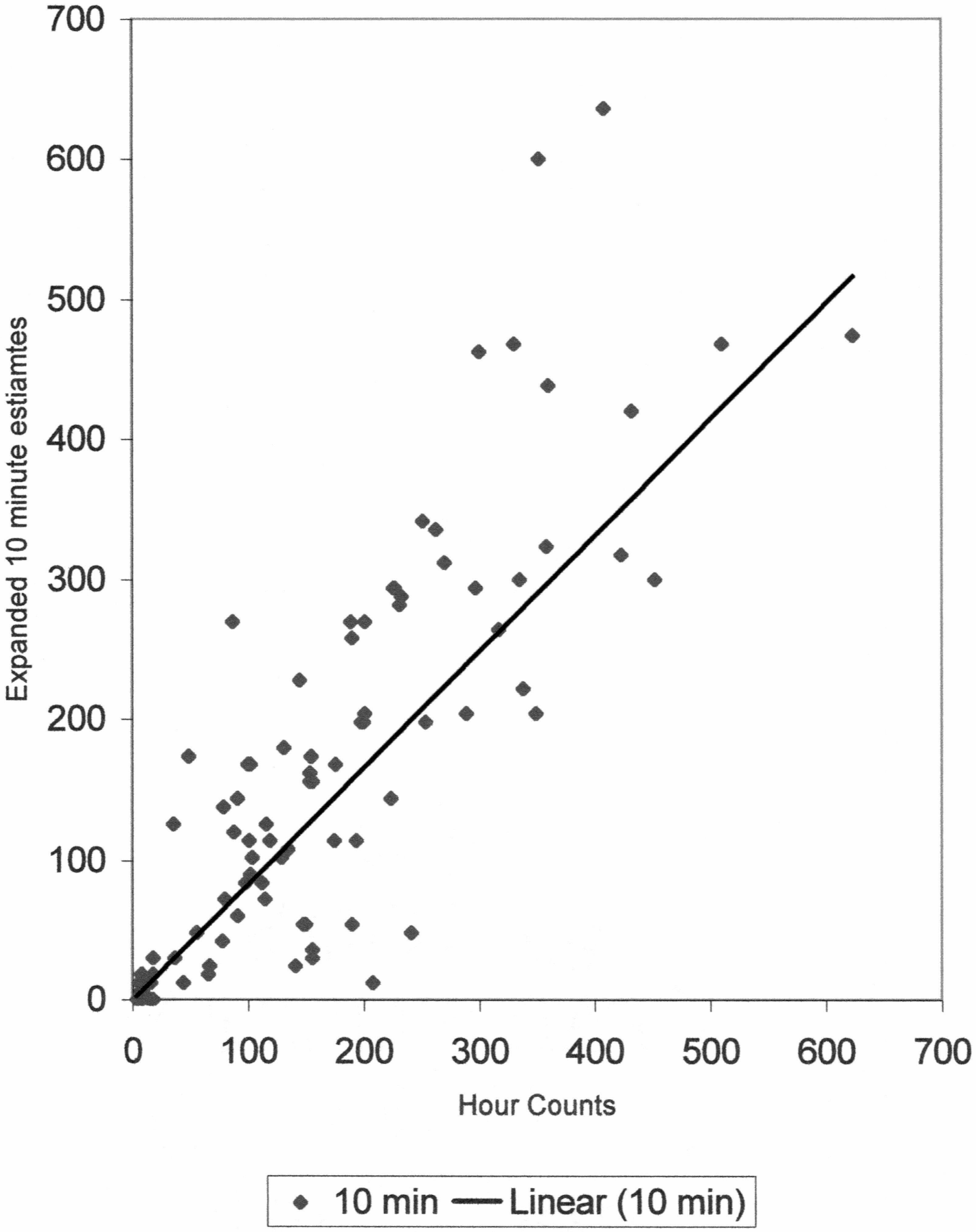

Figure 4: Variability in expanded 10 minute estimates compared to hour counts, Clear Creek-Hogatza River

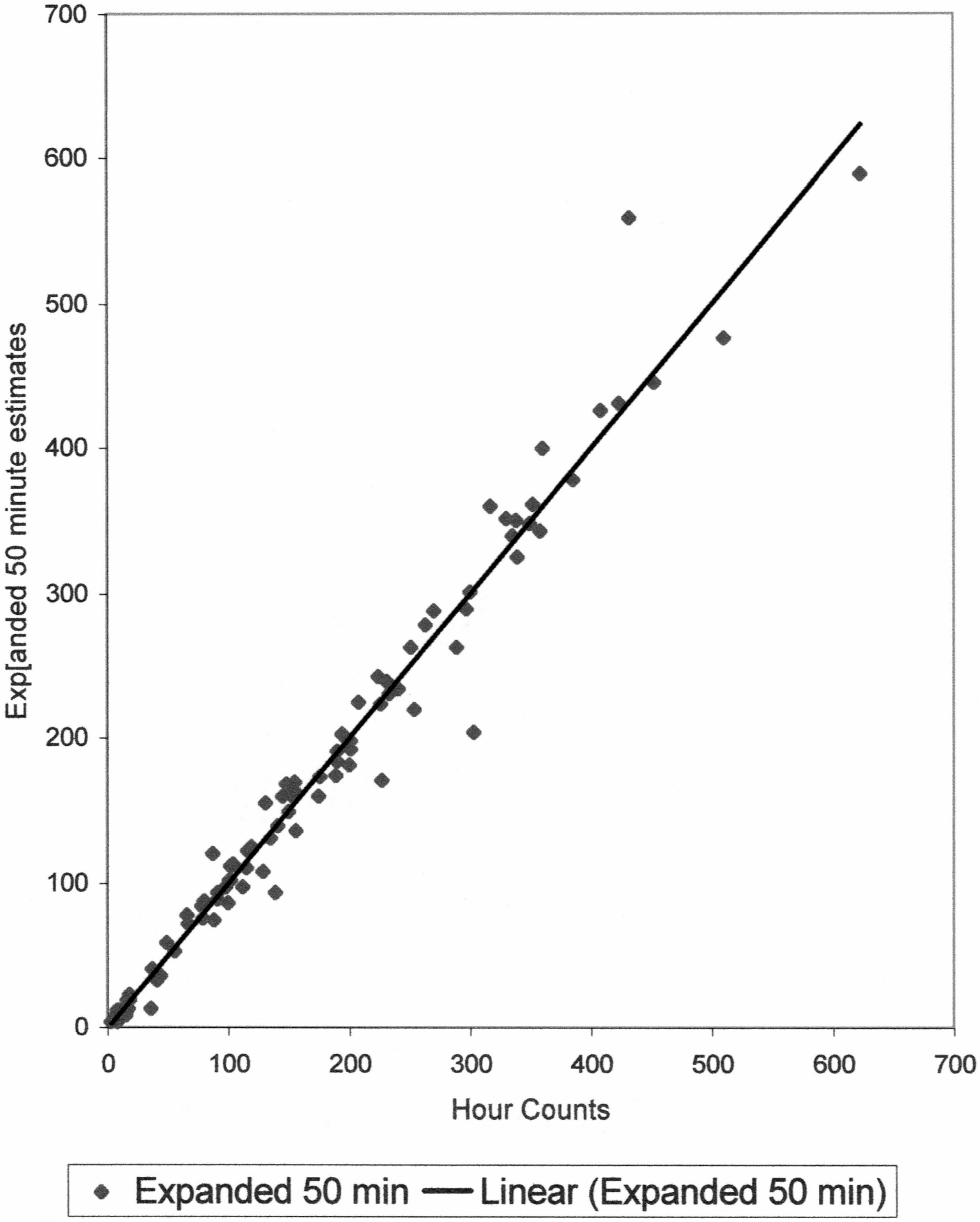

Figure 5: Variability in expanded 50 minute estimates compared to hour counts, Clear Creek-Hogatza River

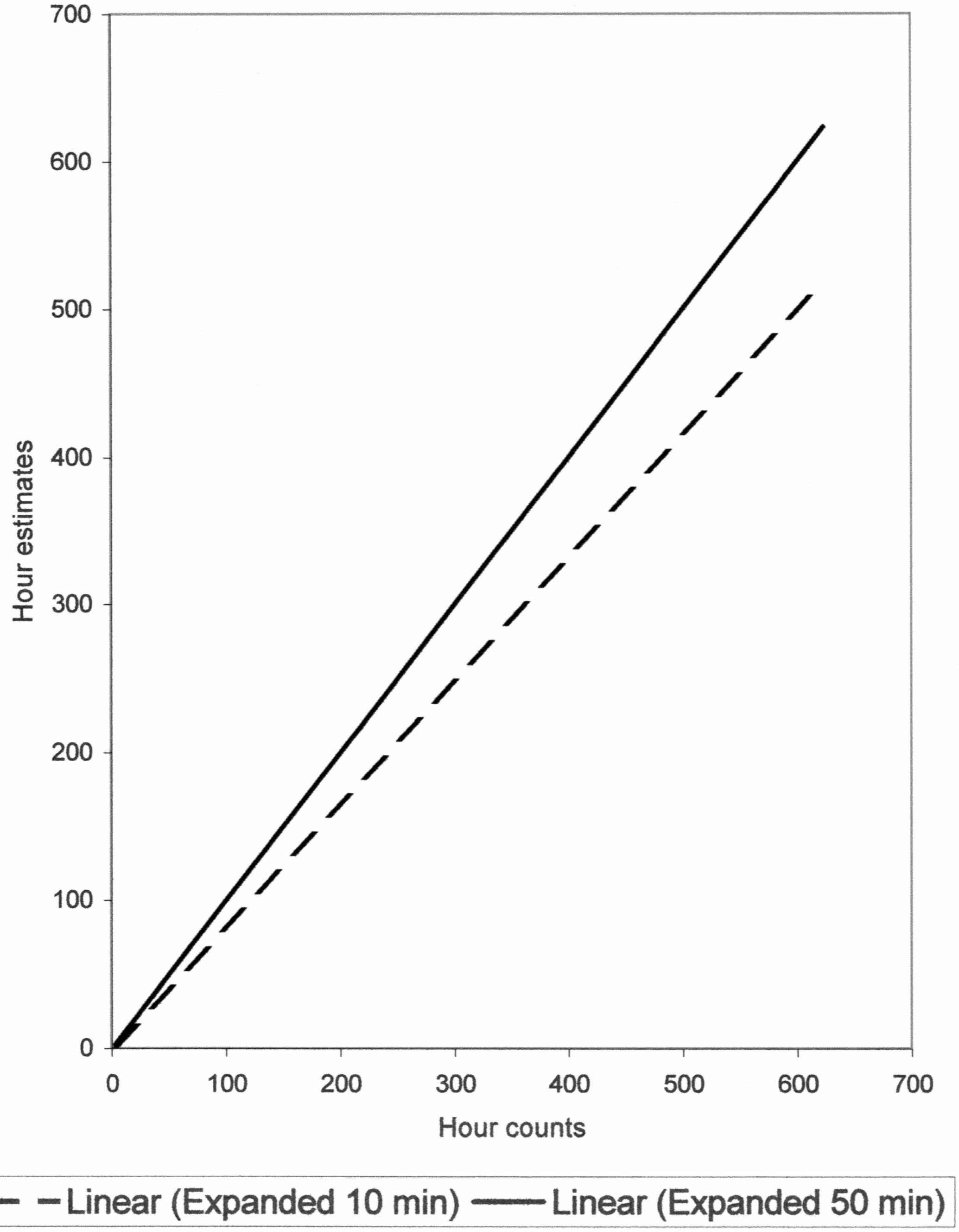

Figure 6: Relationship of 10 and 50 minute estimates to hour counts, Clear Creek-Hogatza River

Table 1: 1995, 1996, and 1997 daily summer chum salmon estimates, Clear Creek-Hogatza River

Date	1995 Daily Estimate	1996 Daily Estimate	1997 Daily Estimate
21-Jun		685	
22-Jun	26	661	
23-Jun	53	2501	
24-Jun	66	710	40
25-Jun	261	4825	179
26-Jun	944	4186	155
27-Jun	2257	4943	281
28-Jun	1847	5308	1072
29-Jun	2435	5919	3615
30-Jun	2580	6586	4286
01-Jul	3944	4850	4552
02-Jul	3663	4803	3722
03-Jul	5630	6007	3872
04-Jul	3660	5678	4618
05-Jul	4961	6163	3178
06-Jul	7662	3716	2836
07-Jul	7911	3975	5490
08-Jul	7640	4336	6670
09-Jul	6144	3521	4640
10-Jul	6806	3743	4371
11-Jul	6574	2958	3007
12-Jul	7659	2162	4257
13-Jul	6366	2366	1939
14-Jul	6257	1955	2079
15-Jul	5098	1634	3051
16-Jul	4164	1726	2449
17-Jul	4658	1659	2741
18-Jul	2053	2079	1609
19-Jul	2261	1257	1067
20-Jul	2007		678
21-Jul	1148		
22-Jul			
Total Estimate	116735	100912	76454

Table 2: Summary of statistical tests conducted on data collected from 1997, Clear Creek-Hogatza River

	Partial Hour Counts								
Statistical Test	10	15	20	25	30	35	40	45	50
	Chi Square (χ^2)								
Calculated Value	1781	1412	1126	809	634	493	286	177	177
Crit. Val. ($\chi^2_{0.05,103}$ = 128)									
	ANOVA								
P-Value (α = 0.05)	0.21	0.38	0.73	0.77	0.99	0.91	0.97	0.98	0.99
F-Value (F_{crit} = 3.89)	1.55	0.76	0.12	0.08	0.00	0.01	0.00	0.00	0.00
	Relative Error								
Relative Error	-16.98	-10.91	-4.21	-3.44	-0.10	1.31	0.43	-0.30	-0.13
Z-Test (Crit Val = 1.983)	-2.33	-1.85	-0.84	-0.41	-0.12	0.649	-0.24	-0.64	-0.34
Z-test P-value	0.02	0.06	0.41	0.68	0.90	0.52	0.81	0.53	0.73
	Correlation variables								
Coefficient (r)	0.63	0.76	0.84	0.90	0.94	0.96	0.98	0.99	0.99
Determination (r^2)	0.40	0.58	0.70	0.81	0.88	0.92	0.96	0.98	0.97
Non-determination (k^2)	0.60	0.42	0.30	0.19	0.12	0.08	0.04	0.02	0.03

Table 3: Percentage of age composition per stratum for 1996 and 1997, Clear Creek-Hogatza River

1996

	0.3	0.4	0.5	Un	Total
Stratum 1	28	41	3	88	160
Percent of sample	18%	26%	2%	55%	100%
Stratum 2	68	37	2	53	160
Percent of sample	43%	23%	1%	33%	100%
Stratum 3	104	26	3	25	158
Percent of sample	66%	16%	2%	16%	100%
Total	200	104	8	166	478
Percent	42%	22%	2%	35%	100%

1997

	0.3	0.4	0.5	Un	Total
Stratum 1	17	58	3	2	80
Percent of sample	21%	73%	4%	3%	100%
Stratum 2	10	66	0	4	80
Percent of sample	13%	83%	0%	5%	100%
Stratum 3	36	73	0	11	120
Percent of sample	30%	61%	0%	9%	100%
Stratum 4	15	37	0	1	53
Percent of sample	28%	70%	0%	2%	100%
Total	78	234	3	18	333
Percent	23%	70%	1%	5%	100%

Table 4: Sex ratio and age composition of summer chum salmon sampled from 1996 and 1997, Clear Creek-Hogatza River

1996

			Age			
		0.3	0.4	0.5	Unreadable	Total
Male	Sample Size	81	44	3	76	204
	Percent total sample	17%	9%	1%	28%	43%
Female	Sample Size	119	60	5	90	274
	Percent total sample	25%	13%	1%	19%	57%
	Total	200	104	8	166	478
	Percent of sample	42%	22%	2%	35%	100%

1997

			Age			
		0.3	0.4	0.5	Unreadable	Total
Male	Sample Size	43	135	3	6	187
	Percent total sample	13%	41%	1%	2%	56%
Female	Sample Size	35	99	0	12	146
	Percent total sample	11%	30%	0%	4%	44%
	Total	78	234	3	18	333
	Percent toal sample	23%	70%	1%	5%	100%

Table 5: Sex ratios of summer chum salmon separated by strata for 1996, Clear Creek Hogatza River

1996					
Stratum 1	0.3	0.4	0.5	Un	Total
Female	10	19	2	39	70
Percent of sample	6%	12%	1%	24%	44%
Male	18	22	1	49	90
Percent of sample	11%	14%	1%	31%	56%
Total	28	41	3	88	160
Percent of sample	18%	26%	2%	55%	100%
Stratum 2					
Female	31	21	1	33	86
Percent of sample	19%	13%	1%	21%	54%
Male	37	16	1	20	74
Percent of sample	23%	10%	1%	13%	46%
Total	68	37	2	53	160
Percent of sample	43%	23%	1%	33%	100%
Stratum 3					
Female	78	20	2	18	118
Percent of sample	49%	13%	1%	11%	75%
Male	26	6	1	7	40
Percent of sample	16%	4%	1%	4%	25%
Total	104	26	3	25	158
Percent of sample	66%	16%	2%	16%	100%

Table 6: Sex ratios of summer chum salmon separated by Strata for 1997, Clear Creek-Hogatza River

1997					
Stratum 1	0.3	0.4	0.5	Un	Total
Female	7	19	0	2	28
Percent of sample	9%	24%	0%	3%	35%
Male	10	39	3	0	52
Percent of sample	13%	49%	4%	0%	65%
Total	17	58	3	2	80
Percent of sample	21%	73%	4%	3%	100%
Stratum 2					
Female	1	17	0	3	21
Percent of sample	1%	21%	0%	4%	26%
Male	9	49	0	1	59
Percent of sample	11%	61%	0%	1%	74%
Total	10	66	0	4	80
Percent of sample	13%	83%	0%	5%	100%

Table 7: Sex ratios of summer chum salmon separated by strata for 1997, Clear Creek-Hogatza River

1997					
Stratum 3	**0.3**	**0.4**	**0.5**	**Un**	**Total**
Female	20	41	0	6	67
Percent of sample	17%	34%	0%	5%	56%
Male	16	32	0	5	53
Percent of sample	13%	27%	0%	4%	44%
Total	36	73	0	11	120
Percent of sample	30%	61%	0%	9%	100%
Stratum 4					
Female	7	22	0	1	30
Percent of sample	13%	42%	0%	2%	57%
Male	8	15	0	0	23
Percent of sample	15%	28%	0%	0%	43%
Total	15	37	0	1	53
Percent of sample	28%	70%	0%	2%	100%

Table 8: Length at age of summer chum salmon for 1996, Clear Creek Hogatza River

	Males				Females			
	Mid-eye to Fork Length				Mid-eye to Fork Length			
Age	N	Mean	SE	Range	N	Mean	SE	Range
0.3	43	580	3.53	520-649	60	581	2.19	530-660
0.4	135	605	4.35	550-670	119	554	3.43	495-630
0.5	3	630	20.21	605-670	5	575	10.49	540-600
Unreadable	76	601	3.52	525-680	90	572	2.86	500-650
Total	204	598	2.26	520-680	274	567	1.68	495-660

Table 9: Length at age of summer chum salmon for 1997, Clear Creek Hogatza River

	Males				Females			
	Mid-eye to Fork Length				Mid-eye to Fork Length			
Age	N	Mean	SE	Range	N	Mean	SE	Range
0.3	43	580	4.04	523-649	35	553	3.72	506-598
0.4	135	605	2.54	534-688	99	570	2.04	520-630
0.5	3	633	11.14	611-647	0	0	0.00	0
Unreadable	6	596	9.78	569-632	12	568	9.22	530-625
Total	187	600	2.23	523-688	146	566	1.89	506-630

Table 10: Hydrological and climatological data for 1996, Clear Creek -Hogatza River

Date	Precip. (cm)	Air Tem (°C)	Water Temp (°C)	Water Height (m)	pH	Turb (NTU)
22-Jun	0.00	26.0	9.00	0.60	7.25	3.58
23-Jun	0.00	24.0	11.00	0.61	7.34	3.33
24-Jun	0.00	25.0	9.00	0.58	7.37	3.29
25-Jun	0.00	21.0	9.00	0.59	7.53	3.31
26-Jun	0.25	20.5	9.00	0.60	7.05	3.38
27-Jun	0.40	18.0	10.00	0.58	7.16	3.37
28-Jun	0.00	15.0	9.00	0.60	7.26	4.45
29-Jun	0.00	17.5	9.00	0.61	7.27	3.39
30-Jun	0.00	19.0	9.00	0.73	7.21	4.56
01-Jul	0.00	20.0	9.00	0.76	7.20	5.52
02-Jul	0.00	21.0	10.00	0.59	7.23	4.49
03-Jul	0.00	24.0	11.00	0.56	7.38	4.48
04-Jul	0.00	22.0	11.00	0.53	7.65	6.65
05-Jul	0.00	21.0	11.00	0.52	7.48	4.68
06-Jul	0.00	23.5	11.00	0.51	7.33	3.38
07-Jul	0.00	25.0	12.00	0.50	7.77	4.46
08-Jul	0.00	25.0	12.00	0.52	7.61	4.45
09-Jul	0.00	21.0	12.00	0.56	7.75	4.48
10-Jul	1.65	19.0	12.00	0.71	7.80	6.66
11-Jul	0.00	23.0	11.00	0.82	7.85	20.00
12-Jul	0.00	19.0	10.00	0.70	7.88	13.13
13-Jul	0.00	19.0	10.00	0.64	7.79	10.00
14-Jul	0.00	19.0	10.00	0.56	7.78	6.32
15-Jul	0.00	18.5	10.00	0.59	7.79	4.00
16-Jul	0.00	19.0	11.50	0.56	7.59	4.31
17-Jul	0.00	16.5	10.00	0.53	7.48	4.48
18-Jul	0.00	21.0	12.00	0.49	6.93	3.30
19-Jul	0.00	19.0	13.00	0.49	7.08	3.36
Total	2.30	581.50	292.50	16.67	208.81	150.81
Average	0.08	20.77	10.45	0.60	7.46	5.39

Table 11: Hydrological and climatological data for 1997, Clear Creek-Hogatza River

Date	Precip. (cm)	Air Temp (°C)	Water Temp (°C)	Water Height (m)	pH	Turb (NTU)
22-Jun	0.00	22.0	11.0	0.70	6.58	3.27
23-Jun	0.00	27.0	9.0	0.68	6.17	4.10
24-Jun	0.00	27.0	11.0	0.67	6.62	3.27
25-Jun	0.00	27.0	11.5	0.66	6.88	2.72
26-Jun	0.00	25.0	11.5	0.65	7.03	3.07
27-Jun	0.00	22.0	10.5	0.64	6.87	3.51
28-Jun	0.00	22.0	11.5	0.64	6.92	2.98
29-Jun	0.00	23.0	12.0	0.63	6.77	2.77
30-Jun	0.00	25.0	11.5	0.63	6.45	2.94
01-Jul	0.00	28.0	11.5	0.62	6.48	3.48
02-Jul	0.00	18.0	12.0	0.61	6.88	4.75
03-Jul	0.00	25.0	11.5	0.62	6.66	5.40
04-Jul	0.00	26.0	13.0	0.61	6.40	6.39
05-Jul	0.00	26.5	13.5	0.61	6.77	4.53
06-Jul	0.00	20.0	12.0	0.60	6.50	4.35
07-Jul	0.00	22.5	11.5	0.60	6.47	4.12
08-Jul	0.00	20.0	11.5	0.60	6.23	3.30
09-Jul	0.20	14.5	10.0	0.65	6.40	3.95
10-Jul	2.20	13.0	8.5	0.66	6.50	8.70
11-Jul	0.40	15.0	6.0	0.68	NA	12.25
12-Jul	0.00	18.0	9.5	0.64	NA	10.60
13-Jul	0.15	10.0	6.5	0.64	NA	9.80
14-Jul	0.00	18.0	8.0	0.63	NA	9.43
15-Jul	0.00	18.0	12.0	0.63	NA	9.04
16-Jul	0.00	24.0	10.5	0.62	NA	7.50
17-Jul	0.00	25.0	11.0	0.62	NA	6.65
18-Jul	0.00	20.5	10.0	0.63	NA	8.45
19-Jul	0.00	23.0	11.0	0.62	NA	9.05
20-Jul	0.00	25.0	10.0	0.61	NA	7.10
Total	2.95	630.00	309.00	18.40	125.58	167.47
Average	0.10	21.72	10.66	0.63	6.61	5.77